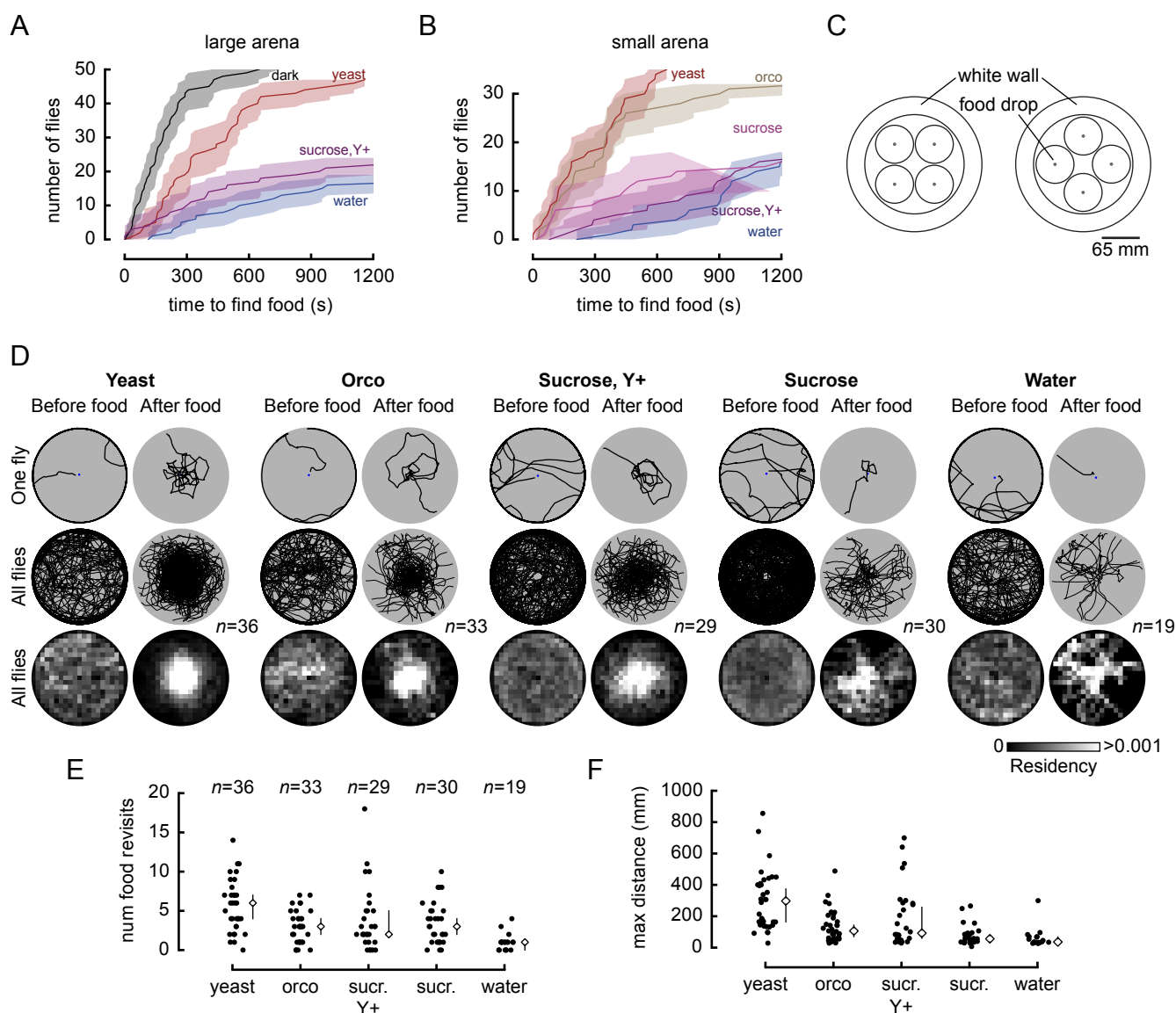


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**Supplemental Information**

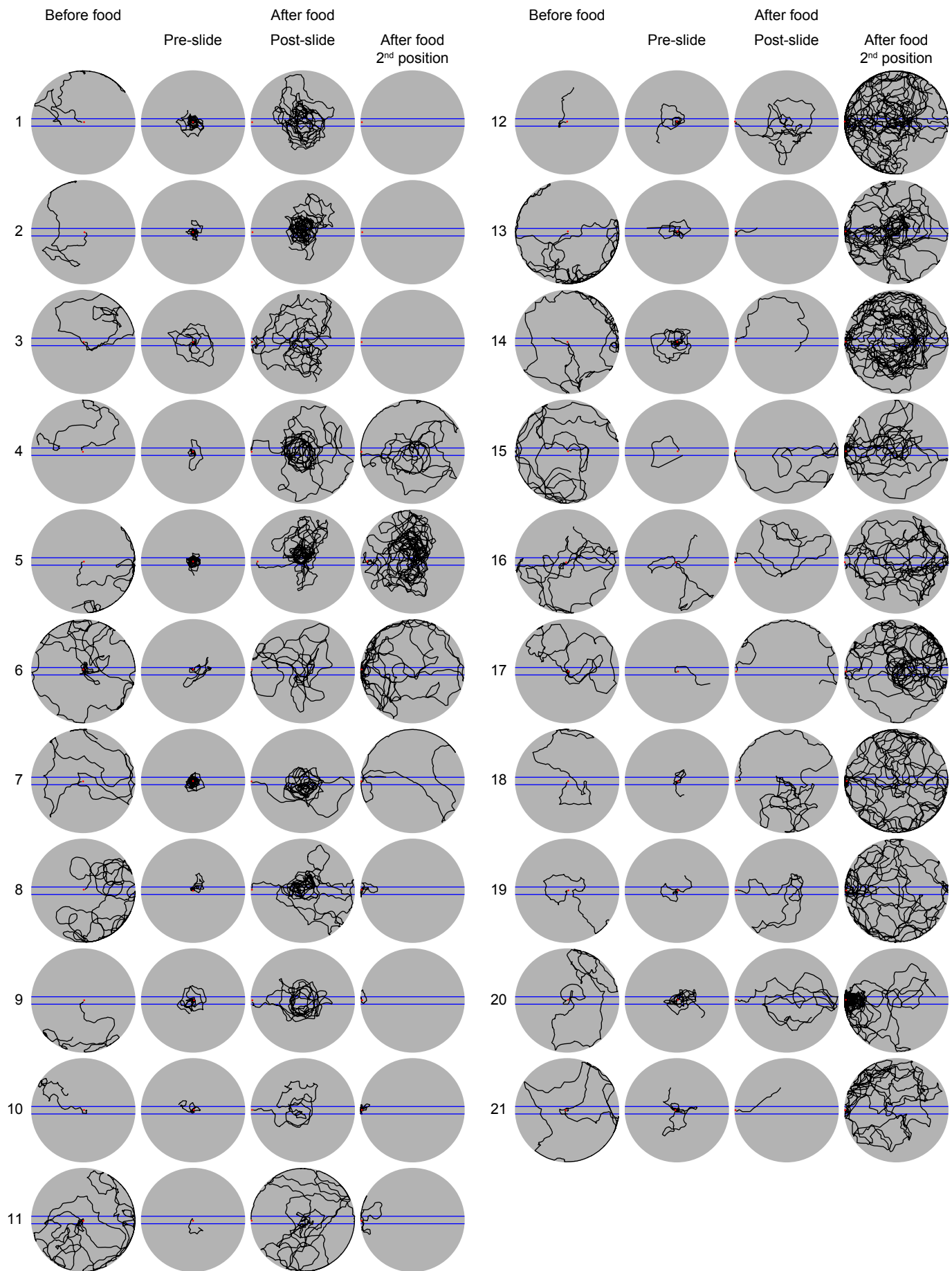
**Idiothetic Path Integration  
in the Fruit Fly *Drosophila melanogaster***

**Irene S. Kim and Michael H. Dickinson**



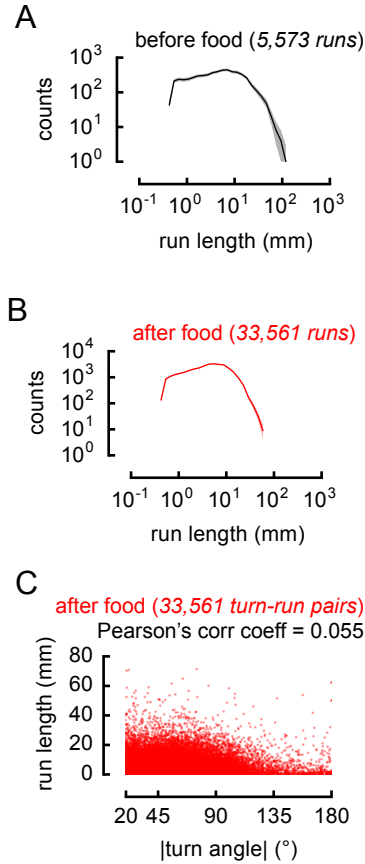
**Figure S1. Time to find food and small arena results. Related to Figure 1.**

(A) Cumulative traces of time to first encounter with food or water in the large arena (170 mm). The first food encounter is defined as stopping for at least 0.2 s within 1.5 mm of the food drop. Flies found the yeast drop faster than they found the sucrose or water drop. They also found the yeast drop faster in the dark than in the light. As in all panels, data are plotted as median and 95% confidence intervals. Y+ signifies that the flies' diet was supplemented with extra yeast prior to starvation so that they would preferentially seek sucrose over yeast. (B) Cumulative traces of time to first encounter with food or water in the small arena (65 mm dia). Wild type flies and *orco*<sup>-</sup> flies took a similar amount of time to find the yeast drop. Flies are slower at finding the sucrose drop regardless of their nutritional state (sucrose vs. sucrose (Y+) traces). Flies are equally as slow at finding the water drop as the sucrose drop. (C) The large arena (170 mm dia) was divided into four small arenas by insertion of a laser-cut acrylic piece. The acrylic piece could be inserted in two different rotational configurations (left and right). A 1  $\mu$ L drop of food was placed at the center of each small arena. A featureless white wall surrounded the boundary of the large arena (see Fig 1A). Imaging and illumination were the same as described in Fig 1. (D) Walking trajectories and residence probabilities of flies encountering a 1  $\mu$ L food drop (5% yeast in the yeast and *orco*<sup>-</sup> trials; 500 mM sucrose in the sucrose and sucrose (Y+) trials); water drop in the small arena trails. Each trial was for 30 m. Top row: trajectories of individual flies. Middle row: trajectories of all flies (yeast: N=36 flies, *orco*<sup>-</sup>: N=33 flies, sucrose (Y+): N=29 flies, sucrose: N=30 flies, water: N=19 flies). Bottom row: Mean residence probabilities for each group of flies. Each probability histogram depicts the mean of the normalized residence probability distributions of individual flies. In calculating the distributions for the before food and water conditions, we did not include any trajectories along the outer wall. (E) Number of revisits to the food or water drop in the small arena. Values for individual flies are plotted as black dots. The median for each condition is plotted as an open diamond; error bars depict 95% confidence intervals. (F) The maximum distance walked between departure from the food or water drop to arrival at the arena wall in the small arena. Plotting conventions as in panel E.



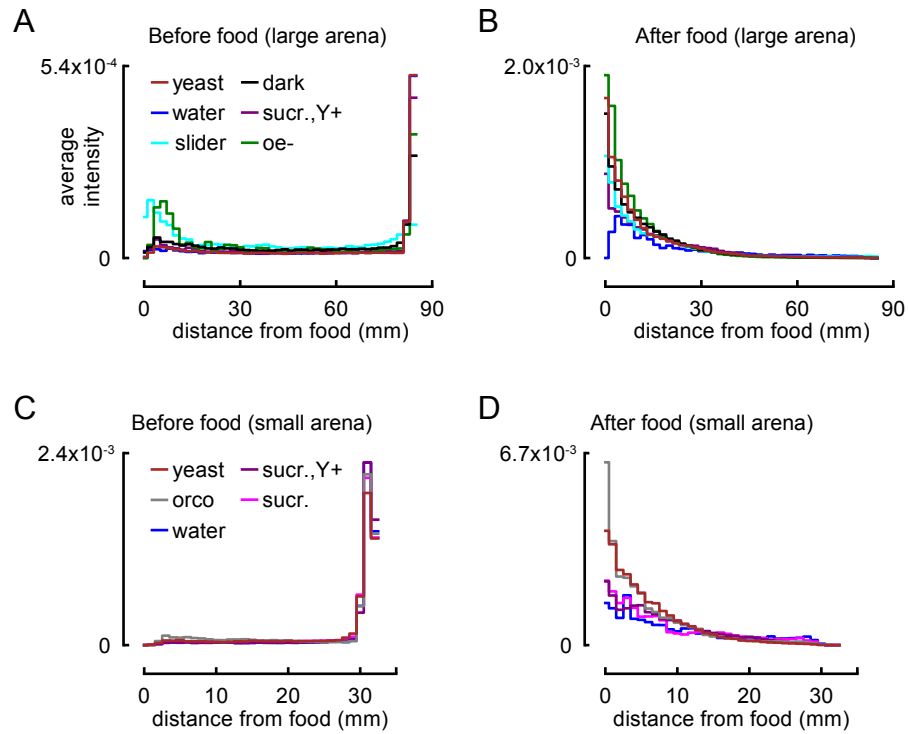
**Figure S2. All individual trajectories for the food slider experiments. Related to Figure 3.**

Each row shows the trajectories for one fly walking the arena in which the food spot was moved after the start of the local search (see Fig 3). The first column shows the flies' paths before they found the food. The second column shows the flies' paths after they left the food, but before the food was moved. The third column shows the flies' paths after the food was moved from the arena center, but before the flies re-encountered the food spot at its new location. The fourth column shows the flies' paths after they encounter the food at the new location. No trajectory is shown if the fly never re-encountered the food in its new location. The blue lines indicated the boundaries of the sliding piece on which the food drop was placed. Each trial was for 45 m.



**Figure S3. Run lengths do not fit a Levy distribution and do not correlate with the preceding turn angle. Related to Figure 4.**

(A) Distribution of run lengths from before food trajectories for all yeast trials plotted on a log-log scale. Data are the same as in Fig 4C (n=101 flies; 5,573 runs). (B) Distribution of run lengths from all trajectories after food contact for all yeast trials plotted on a log-log scale. Data are the same as in Fig 4C (n=101 flies; 33,561 runs). (C) Scatter plot of the absolute value of a turn angle and the run length following that turn. Turn-run pairs are taken from the trajectories after food contact for all yeast trials (n=101 flies, 33,561 turn-run pairs). The Pearson's correlation coefficient is 0.055.



**Figure S4. Radial distributions. Related to Figures 1, 2, 3, and S1.**

Radial averages of mean residence probabilities shown in Fig. 1B, 2A, 3B, S1D (bottom rows). (A) Radial averages for the ‘before food’ residence probabilities for flies in the large arena (170 mm dia). (B) Radial averages for the ‘after food’ residence probabilities for flies in the large arena (170 mm dia). For the slider case, the after food, pre-slide and post-slide data were combined. (C) Radial averages for the ‘before food’ residence probabilities for flies in the large arena (65 mm dia). (D) Radial averages for the ‘after food’ residence probabilities for flies in the large arena (65 mm dia).

Large arena, after food								Small arena, after food					
		Expected								Expected			
		yeast	water	dark	sucrose	oe-	slider			yeast	orco	water	sucr,Y+
Observed	yeast	$\chi^2 = 0.00$ p = 1.00	1.87x10 <sup>16</sup> 0.00	8.96 1.00	139.97 0.00	44.84 0.04	62.05 0.00	Observed	yeast	$\chi^2 = 0.00$ p = 1.00	13.25 1.00	177.44 0.00	71.99 0.00
	water	245.78 0.00	0.00 1.00	233.76 0.00	119.85 0.00	409.43 0.00	142.58 0.00		orco	20.02 0.95	0.00 1.00	272.83 0.00	126.12 0.00
	dark	9.36 1.00	1.52x10 <sup>16</sup> 0.00	0.00 1.00	92.58 0.00	52.88 0.01	39.21 0.12		water	122.42 0.00	99.37 0.00	0.00 1.00	38.73 0.19
	sucrose	78.55 0.00	5.18x10 <sup>15</sup> 0.00	58.97 0.00	0.00 1.00	182.40 0.00	21.03 0.89		sucr,Y+	0.08 43.74	0.01 55.83	0.55 30.37	1.00 0.00
	oe-	52.07 0.01	2.45x10 <sup>16</sup> 0.00	72.13 0.00	397.71 0.00	0.00 1.00	223.08 0.00		sucr	0.00 73.16	0.00 65.52	0.97 18.76	0.97 18.85
	slider	42.44 0.07	7.63x10 <sup>15</sup> 0.00	29.59 0.49	22.99 0.82	132.07 0.00	0.00 1.00						

**Table S1. Statistical analysis of ‘after food’ radial averages. Related to Figure S4.**

(A) Pairwise chi-squared tests were performed on the ‘after food’ radial averages in the large arena (170 mm dia) shown in Figure S4B. Chi-squared values and p-values are reported in the table. A p-value of 1 signifies that the curves likely result from the same underlying distribution. We interpret the p-values as a measure of how similar the curves are. (B) Pairwise chi-squared tests were performed on the ‘after food’ radial averages in the small arena (65 mm dia) shown in Figure S4D.